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STUDIES OF THE TERRESTRIAL ENVIRONMENT IN THE VICINITY OF THE ELDORADO RESOURCES LTD. REFINERY AT BLIND RIVER, ONTARIO 1981-1984

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Studies of the Terrestrial Environment in the Vicinity of the Eldorado Resources Ltd. Refinery at Blind River, Ontario

1981-1984

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STUDIES OF THE TERRESTRIAL ENVIRONMENT IN THE VICINITY OF THE ELDORADO RESOURCES LTD. REFINERY AT BLIND RIVER

I Summary

In 1981, the Ontario Ministry of the Environment initiated a program to obtain background data on soils and vegetation in the vicinity of the Eldorado Resources Ltd. (E.R.L.) uranium refinery prior to the operational start-up of the complex. A total of seven plot sites were selected where 20 trees of each of trembling aspen and white pine (where available) were tagged, measured and evaluated annually for condition and growth. Soil and vegetation (foliage of white pine, trembling aspen and forage) samples have been collected annually at six of the tree plot sites and analyzed for 11 elements including uranium, copper, nickel, lead, cobalt, zinc, iron, sulphur, calcium, magnesium and potassium. Of the elements tested, only uranium showed an increase in concentration in foliage samples collected in close proximity to the refinery (on E.R.L. property) following the start-up of the facility. These concentrations of uranium, although above background values, are not of concern at this time and are not toxic to the vegetation; however, they do indicate that uranium is deposited from refinery emissions on E.R.L. property and that it is being retained in the foliage of vegetation. The situation therefore warrants continued monitoring to ensure that the deposition of uranium from the E.R.L. refinery will not pose any adverse environmental impact.

II Introduction

In 1978, the proposal by Eldorado Resources Ltd. to build a uranium hexafluoride refinery in Ontario was subject to environmental assessment studies and public review. Three possible sites for the refinery were selected for review, and the site at Blind River was finally selected.

The original proposal was that the rifinery would produce uranium hexafluoride (UF_6). Subsequent to the decision that the refinery would be built at Blind River, it was decided that the new refinery would produce only the intermediary product, uranium trioxide (UO_3), at a rate of 18,000 tonnes per year. Operations began in the summer of 1983.

As part of the overall monitoring program to determine if emissions from the refinery would affect the environment, the Ontario Ministry of the Environment initiated a variety of monitoring surveys prior to the start-up of operations. In 1981, a network of permanent tree plots was established in the vicinity of the refinery, and samples of vegetation and soil were collected for chemical analysis. This sampling program has been continued, and the present report covers results obtained in both the pre-operational and post start-up periods.

III Permanent Vegetation Plots

i) Plot Establishment

In August, 1981, following a visual reconnaissance of the area, six sites were selected for establishment of permanent vegetation plots. These sites are shown in Figure 1 and are located as follows with respect to the refinery.

Plot Number	Location
1	100 m NW
2	200 m NE
3	1200 m NE
4	300 m S
5	900 m ESE
6	2400 m ENE

Four of the plots are located on property controlled by E.R.L., and three of these are in close proximity to the fence around the complex. Public access to the property is available to the golf course situated northwest of the refinery and at the park area near Patrick Point.

At each plot, 20 semi-mature trembling aspen (Populus tremuloides) were selected for monitoring purposes. White pine (Pinus strobus) was available in sufficient numbers only at Plots 1, 3 and 4. Each of the selected trees was identified with a numbered metal tag held in place with a copper nail. The diameter at breast height (DBH) was measured, recorded and the measurement height marked on each tree with a band of paint. Each tree was evaluated for crown

condition, insect damage, disease and foliage colour. The crown condition ratings are summarized in Table 1.

All trees were re-evaluated in August, 1982, 1983 and 1984, for the same parameters as in 1981. It was discovered in 1982 that the plot at Site 1 had been destroyed during the construction of a golf course. Therefore a new Plot 1 was established approximately 100 m south of the original in August, 1983. A control plot (Plot 7) was selected at a location 10 km east of the refinery. The same techniques were employed during the establishment of the two new plots.

ii) Results

A summary of the size and growth measurements of the trees is presented in Table 2. The mean DBH ranged from 14.6 cm to 27.9 cm for trembling aspen and 13.9 cm for white pine. Growth rates for the most part were similar at all sites, however, growth in 1983 was substantially lower than in 1982. This difference can be attributed to the exceptionally dry conditions which prevailed during the growing season in 1983. Growth in 1984 was greatest at all plots (except Plot 3) in the case of trembling aspen, presumably in response to the extra available moisture during the growing season of 1984. The growth of the white pine also recovered in 1984 did not achieve the rate measured in 1982.

Insect injury to trembling aspen was recorded in each of the years of evaluations. Severity was mainly rated as light, however, the severity appeared to decline in the first years then stabilized or increased slightly in 1984 (Table 3). The following diseases and mortality were noted among the aspen trees:

Plot	Mortality	Hypoxylon Canker	Phellinus Heart Rot
4	-	3	1
5	2	1	1
6	1	1	-

The two trees which died at Plot 6 were lost as the result of the creation of a foot path to the park being developed at Patrick Point. The two disease organisms are common pathogens of trembling aspen.

IV Vegetation and Soil Sampling Program

i) Sampling Procedures

At the time when the tree plot evaluations were made (August) each year, triplicate samples of vegetation foliage (white pine, trembling aspen and forage grasses) and soil (0-5 cm) were collected at each plot location. These samples were returned to the Ministry of the Environment laboratory in Sudbury. Vegetation samples were oven-dried, ground in a Wiley mill and placed in glass jars. The soil samples were air-dried, ground in a mortar and pestle to pass through a 45 mesh sieve and bottled. The samples were then delivered to the laboratory in Toronto for chemical analysis. The analyses included total uranium, copper, nickel, lead, cobalt, zinc, iron, sulphur, calcium, magnesium and potassium.

ii) Results

The results of the chemical analyses are presented for the individual elements in Tables 4 to 14. With the exception of uranium (see below), the concentrations of all elements in all samples were within their normal ranges. There was some variability from site to site but the variation was considered to be normal. The fluctuations in concentrations from year to year were also considered to be normal. The data show that trembling aspen is a natural accumulator of zinc (Table 9) and to a lesser extent cobalt (Table 8) when

compared with the other vegetation species. There is no evidence of accumulation of any of these elements (except uranium in vegetation) in vegetation or soil which might be attributable to emissions from the refinery.

The concentrations of uranium in all species of vegetation, by contrast, show an increase from year to year following the start-up of the refinery. The greatest increases were found in close proximity to the refinery, on property owned by E.R.L. The evidence for accumulation in soil is less definitive, but may become more apparent with time. While the concentrations of uranium measured in the vegetation samples have not reached levels that could be considered as toxic to the plants, they do indicate that deposition of uranium from refinery emissions has occurred since it became operational, and that uranium is being retained in the foliage of vegetation. The concentrations of uranium which might be toxic to the plant species growing in the area are not known. The highest concentration of uranium observed in vegetation and soil for the 1984 collection was 5.69 ug/g (trembling aspen foliage) and 1.16 ug/g respectively (see Table 4).

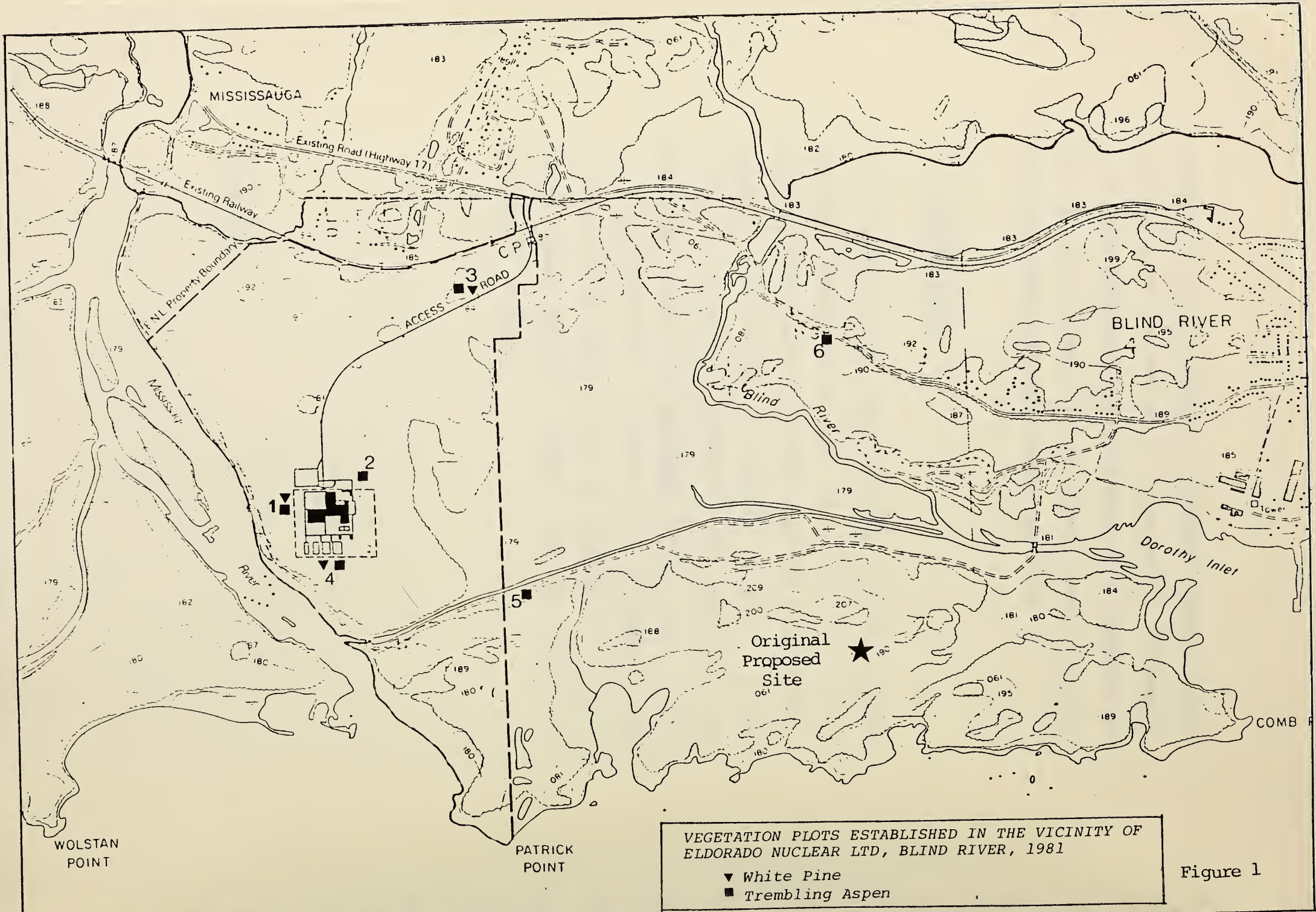
It should be noted that the uranium emissions from the E.R.L. refinery stacks are well below the Federal action level limits (Eldorado Resources Ltd., Blind River Refinery, Fourth Quarter Report, 1984). Although the emitted amounts of

uranium are low, the foliage of vegetation growing in close proximity to the refinery is able to accumulate the element. It is not known whether the values measured in vegetation in 1984 represent the upper limit of concentrations which might be achieved under the current rate of emissions.

V Recommendations

It is recommended that this vegetation and soil sampling program be repeated on an annual basis for a few years in order to follow closely the recently observed accumulation of uranium in the foliage of vegetation on E.R.L. refinery property. It is also recommended that additional plant species be considered for sampling to provide a more complete set of baseline values. In addition, it is recommended that a review of the sampling sites be undertaken in order to better assess potential impacts from the refinery at off-property locations.

VI Appendix



VEGETATION PLOTS ESTABLISHED IN THE VICINITY OF ELDORADO NUCLEAR LTD, BLIND RIVER, 1981

▼ *White Pine*
■ *Trembling Aspen*

Figure 1

TABLE 1

Crown condition classification system
for coniferous and hardwood trees

Rating	Description
1	Near perfect specimen tree
2	High quality forest tree with self pruning of shaded branches
3	Tree in good condition, may have one or 2 dead branches
4	Tree in fair to moderate condition with three or more dead branches
5	Up to one half of crown dead
6	One half of 75% of crown dead
7	75 - 90% of crown dead
8	Over 90% of crown dead, some branches retained foliage
9	Branches with few live needles/leaves still attached
10	Tree dead, branches still mainly intact

TABLE 2

Summary of size* and growth of trees in plots established in the vicinity of the Eldorado Resources uranium refinery at Blind River

		Increase in Diameter							
		Trembling Aspen				White Pine			
Plot #	Year of Establishment	DBH**	1982	1983	1984	DBH	1982	1983	1984
1	1983	14.6	-	-	.72	13.9	-	-	.34
2	1981	18.7	.29	.05	.42	-	-	-	-
3	1981	16.2	.45	.02	.41	32.1	.31	.09	.18
4	1981	20.0	.44	.04	.49	16.9	.32	.05	.24
5	1981	24.8	.45	.24	.61	-	-	-	-
6	1981	16.0	.37	.21	.52	-	-	-	-
7	1983	27.9	-	-	.28	18.3	-	-	.57

* All measurements reported as cm

** DBH - Diameter at breast height

TABLE 3

Summary of insect severity ratings for trembling aspen plots in the vicinity of the Eldorado Resources uranium refinery, Blind River

Plot	Year			
	1981	1982	1983	1984
1	(light)*	-	trace	light
2	light	light	trace	light
3	light - moderate	light	light	trace - light
4	light - moderate	light - moderate	light	light
5	light - moderate	light - moderate	light	light
6	light	light	trace - light	light
7	-	-	light	light

* Based on ratings on original plot

TABLE 4

Concentrations of uranium (ug/g)*in vegetation and soil samples collected in the vicinity of the Eldorado Resources uranium refinery at Blind River - 1981 to 1984

	Trembling Aspen				White Pine				Forage				Soil			
Site	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984
1	<1	.04	.25	1.33	<1	.03	.42	.51	<1	.03	.05	.69	<1	.85	.32	.69
2	<1	.03	1.5	5.69	<1	.05	1.32	2.91	<1	.05	1.05	2.44	<1	.45	.35	1.16
3	<1	.05	.06	.28	<1	.04	.05	.06	<1	.01	.06	1.24	1	.31	.25	.55
4	<1	.02	.09	2.67	<1	.01	.13	.52	<1	.01	.14	1.08	1	.55	.54	.80
5	<1	.01	.05	.20	-	-	.03	.16	<1	<.01	.05	.10	1.3	1.58	.93	.57
6	<1	<.01	.03	.06	<1	.01	.03	.06	<1	.01	.03	<.05	1	.29	<.25	.34
Control			<.02	<.05			<.02	<.05			<.02	<.05			.30	.77

* results are reported as the mean of triplicate samples.

TABLE 5

Concentrations of copper (ug/g)* in vegetation and soil samples collected in the vicinity of the Eldorado Resources uranium refinery at Blind River - 1981 to 1984

Site	Trembling Aspen				White Pine				Forage				Soil			
	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984
1	9	8	7	11	5	4	3	4	4	3	3	5	13	14	13	18
2	10	13	17	8	5	4	5	4	7	3	3	3	13	10	9	16
3	6	8	7	6	4	3	4	4	2	2	3	2	18	19	14	32
4	6	9	8	6	6	2	4	4	4	4	3	2	8	7	17	18
5	9	10	13	10	-	-	5	4	2	4	4	4	11	17	10	13
6	9	12	15	8	3	4	5	4	2	3	4	2	15	13	10	14
Control				12				4				4				35

* results are reported as the mean of triplicate samples.

TABLE 6

Concentrations of nickel (ug/g)*in vegetation and soil samples collected in the vicinity of the Eldorado Resources uranium refinery at Blind River - 1981 to 1984

	Trembling Aspen				White Pine				Forage				Soil			
Site	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984
1	5	8	3	4	3	4	3	2	2	1	2	2	11	9	11	14
2	6	5	8	4	3	2	1	3	2	1	3	1	10	9	9	12
3	4	3	2	5	3	2	2	2	2	2	2	2	21	10	12	18
4	2	4	3	3	3	2	2	3	1	1	1	1	8	7	11	10
5	7	3	5	3	-	-	3	4	2	2	2	4	9	10	8	9
6	13	7	8	4	1	3	3	2	2	3	3	2	13	9	8	10
Control				6				4				2				11

* results are reported as the mean of triplicate samples.

TABLE 7

Concentrations of lead (ug/g)*in vegetation and soil samples collected in the vicinity of the Eldorado Resources uranium refinery at Blind River - 1981 to 1984

	Trembling Aspen				White Pine				Forage				Soil			
Site	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984
1	<2	2	<1	1	<2	2	<1	<1	<2	1	3	<1	17	23	27	33
2	<2	3	2	1	<2	2	2	<1	<2	2	2	<1	9	33	15	21
3	<2	3	1	1	<2	1	1	<1	<2	2	2	1	52	57	45	69
4	<2	3	2	1	<2	2	1	<1	<2	1	1	<1	8	20	36	23
5	<2	3	<1	1	-	-	<1	<1	<2	2	<1	<1	8	25	7	12
6	<2	3	<1	1	<2	2	<1	<1	<2	2	<1	<1	17	31	18	17
Control				1				<1				2				30

* results are reported as the mean of triplicate samples.

TABLE 8

Concentrations of cobalt (ug/g)*in vegetation and soil samples collected in the vicinity of the Eldorado Resources uranium refinery at Blind River - 1981 to 1984

Site	Trembling Aspen				White Pine				Forage				Soil			
	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984
1	4	5	3	5	<1	<1	<1	<1	<1	<1	<1	<1	8	4	4	8
2	4	4	4	4	<1	<1	<1	<1	<1	<1	<1	<1	10	7	2	6
3	3	3	2	3	<1	<1	<1	<1	<1	<1	<1	<1	9	7	5	11
4	2	2	3	3	2	<1	<1	<1	<1	<1	<1	<1	6	4	5	5
5	6	4	7	6	-	-	<1	<1	<1	<1	<1	<1	7	5	2	6
6	6	4	4	5	<1	<1	<1	<1	<1	<1	<1	<1	10	4	2	5
Control				4				<1				<1				11

* results are reported as the mean of triplicate samples.

TABLE 9

Concentrations of zinc (ug/g)*in vegetation and soil samples collected in the vicinity of the Eldorado Resources uranium refinery at Blind River - 1981 to 1984

	Trembling Aspen				White Pine				Forage				Soil			
Site	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984
1	265	143	147	470	53	26	52	45	39	28	31	23	63	33	49	76
2	268	488	473	370	46	46	47	42	23	30	11	15	40	72	45	64
3	189	320	243	273	46	40	61	50	17	24	29	28	90	99	102	123
4	170	195	94	111	43	15	40	31	41	28	28	24	37	39	80	44
5	245	176	370	387	-	-	55	48	31	32	29	29	30	42	28	32
6	214	348	373	307	57	37	43	49	32	27	35	21	35	49	34	53
Control				333				29				35				43

* results are reported as the mean of triplicate samples.

TABLE 10

Concentrations of iron (ug/g)* in vegetation and soil samples collected in the vicinity of the Eldorado Resources uranium refinery at Blind River - 1981 to 1984

Site	Trembling Aspen				White Pine				Forage				Soil			
	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984
1	63	33	39	106	71	17	113	53	152	27	153	70	11600	9100	10333	11333
2	187	60	45	55	279	90	25	104	219	80	11	111	6500	19800	10667	29000
3	201	17	35	63	167	10	12	52	389	53	72	77	13100	13100	14000	24667
4	95	53	28	128	137	13	12	80	195	17	10	49	8400	14300	14333	9500
5	124	40	207	233	-	-	28	81	150	27	117	447	7200	8500	6567	8300
6	77	33	54	105	77	13	10	57	67	10	19	48	11100	11200	7967	11000
Control				106				47				129				15667

* results are reported as the mean of triplicate samples.

TABLE 11

Concentrations of sulphur (%)* in vegetation and soil samples collected in the vicinity of the Eldorado Resources uranium refinery at Blind River - 1981 to 1984.

Site	Trembling Aspen				White Pine				Forage				Soil			
	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984
1	.23	.24	.21	.25	.10	.08	.09	.09	.10	.09	.10	.13	.02	.02	.03	.04
2	.25	.19	.32	.20	.10	.09	.12	.08	.16	.14	.19	.05	.02	.03	.03	.03
3	.26	.20	.18	.18	.10	.09	.10	.10	.10	.11	.07	.11	.03	.03	.04	.06
4	.20	.25	.28	.16	.10	.11	.08	.09	.23	.10	.08	.14	.02	.02	.04	.03
5	.08	.24	.29	.20	-	-	.09	.08	-	.12	.17	.15	.04	.12	.04	.03
6	.23	.30	.33	.24	.10	.10	.37	.10	.13	.12	.13	.18	.03	.03	.02	.04
Control				.17				.07				.09				.05

* results are reported as the mean of triplicate samples.

TABLE 12

Concentrations of calcium (%) *in vegetation and soil samples collected in the vicinity of the Eldorado Resources uranium refinery at Blind River - 1981 to 1984

	Trembling Aspen				White Pine				Forage				Soil			
Site	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984
1	.92	.75	.55	1.83	.26	.17	.21	.21	.22	.16	.14	.33	.25	.24	.28	.37
2	1.00	1.86	1.30	1.60	.23	.23	.22	.26	.22	.30	1.22	.09	.25	.39	.30	.31
3	.73	1.22	.87	.85	.27	.19	.21	.32	.14	.22	.12	.19	.21	.22	.33	.35
4	.97	1.02	.79	.99	.27	.19	.22	.22	.34	.31	.14	.16	.18	.25	.35	.34
5	.98	.60	1.02	1.33	-	-	.18	.32	.23	.18	.58	.29	.22	.36	.26	.30
6	1.12	1.34	1.20	1.50	.42	.26	.27	.35	.30	.15	.67	.31	.20	.30	.13	.19
Control				1.20				.26				.17				.24

* results are reported as the mean of triplicate samples.

TABLE 13

Concentrations of magnesium (%)* in vegetation and soil samples collected in the vicinity of the Eldorado Resources uranium refinery at Blind River - 1981 to 1984

Site	Trembling Aspen				White Pine				Forage				Soil			
	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984
1	.22	.30	.32	.26	.09	.13	.13	.11	.06	.13	.09	.13	.24	.27	.28	.27
2	.26	.36	.50	.44	.09	.13	.15	.12	.08	.12	.06	.05	.26	.35	.32	.36
3	.18	.41	.30	.25	.07	.13	.13	.12	.04	.09	.07	.09	.15	.18	.26	.30
4	.19	.38	.27	.24	.09	.07	.10	.12	.09	.12	.08	.07	.18	.29	.34	.20
5	.21	.30	.44	.25	-	-	.15	.12	.07	.14	.18	.12	.19	.24	.26	.24
6	.16	.39	.52	.35	.11	.16	.17	.14	.09	.06	.10	.07	.32	.22	.15	.21
Control				.25				.09				.09				.15

* results are reported as the mean of triplicate samples.

TABLE 14

Concentrations of potassium (%)*in vegetation and soil samples collected in the vicinity of the Eldorado Resources uranium refinery at Blind River - 1981 to 1984

	Trembling Aspen				White Pine				Forage				Soil			
Site	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984
1	1.30	1.46	1.07	1.48	.50	.52	.52	.51	1.60	1.14	1.11	2.47	.03	.05	.04	.05
2	.33	2.52	3.24	.90	.60	.59	.79	.45	1.76	1.71	1.27	.64	.03	.05	.03	.04
3	1.10	1.56	1.29	.78	.46	.66	.70	.45	.73	.97	1.13	.99	.08	.06	.06	.07
4	.93	1.54	.85	.83	.63	.75	.60	.56	2.13	2.09	1.38	1.16	.03	.04	.06	.04
5	.33	1.18	1.17	.80	-	-	.68	.45	1.80	1.43	1.15	1.40	.03	.06	.03	.06
6	1.00	2.28	2.79	1.06	.50	.59	.68	.61	.96	1.51	3.59	1.01	.06	.07	.05	.05
Control				2.08				.39				1.64				.06

* results are reported as the mean of triplicate samples.

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